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RADIOASTRONOMICAL INVESTIGATIONS AND IONOSPHERE  
OF VENUS

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OF VENUS

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SUMMARY

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The present work is especially devoted to the review of the new data related to the problem of origin of Venus' eigenstrahlung, or own radioemission and its connection with the planet's ionosphere. The author points to a series of indications that the results of radio-astronomical investigations of Venus are apparently linked with the ionosphere, and that it should be taken into account when interpreting experimental data regardless of the model that explain the total spectrum of brightness temperatures of planet's radioemission.

In spite of the fact that the present work is not especially based upon the materials, which, according to the author, point to the presence on Venus of a dense ionosphere, he still believes that they are evidence that the scheme of Venus' ionosphere is more complex than was believed so far, and requires further ascertaining. *Author*

\* \* \*

As is well known, several hypotheses were brought forth for the explanation of high temperatures of Venus' eigenstrahlung. Both, the hotbed and the aelospheric hypotheses and their subsequent modifications assume high surface temperatures, whereas the ionosphere models refer the high temperatures of centimeter radioemission to the high layers of the atmosphere.

In a preceding work by the author [1] it was pointed out that the porous model of the ionosphere, proposed by Danilov and Yatsenko in [2, 3], can explain practically all the available radioastronomical data on Venus. New data appeared in literature in the course of the past year, offering interest for the problem of origin of Venus' eigenstrahlung and its connection with planet's ionosphere. The present work is precisely devoted to the review of these data.

Analysis of data on polarization of Venus' own radioemission in 10.6 cm, obtained by Seielstadt et al [5], is presented in the work by Soboleva and Pariyskiy [4]. This analysis has shown that the indicated data on polarization can be explained, provided we assume the existence around Venus of a ionosphere with a number of electrons along the visual ray equal to  $10^{16} \text{ cm}^{-2}$ . If the effective thickness of the ionosphere is about 100 km, the Soboleva and Pariyskiy's conclusion means, that electron concentrations of the order of  $10^9 \text{ cm}^{-3}$  exist in Venus' ionosphere, that is precisely those required for the ionosphere model. It should, however, be noted, that the reliability of the value of polarization, measured in [5], is not too great ( $\sim 0.06\%$ ).

Clark and Spencer [6] investigated the distribution of radioemission about the disk of Venus in 9.5 cm with the aid of an interferometer with variable base and found, that this distribution cannot be uniform or give a darkening toward the edge. This, apparently, constitutes an argument against the assumption of planet surface as being the source of emission in 9.5 cm, inasmuch as in the case of thermal emission of the surface, darkening toward the edge of Venus should be observed. At the same time, in case of the validity of the porous model of the ionosphere, it would not be possible, generally speaking, to state a priori, what the distribution of brightness temperatures about the disk would be, inasmuch as this would be determined by the distribution of "ionized" clouds in the ionosphere, which is still unknown.

As already indicated in the work by Priester et al [7], a reverse correlation was revealed between the astronomical unit measured at 70 cm and the solar emission flux in 10.7 cm, which is a good indicator of solar activity. The authors of [7] explain the observed

correlation by the reflection of radiowaves with  $\lambda = 70\text{ cm}$  in the ionosphere of Venus, which expands at increase in solar activity and contracts at latter's decrease, as this takes place in the Earth's ionosphere.

An analogous comparison for the value of cross section  $\sigma$  of the reflection obtained by Goldstein during radar location in  $12.5\text{ cm}$  at time of the 1962 conjunction is plotted in Fig.1.

As was stressed in the work [8], the measured value of  $\sigma$  undergoes variations from day to day, exceeding the anticipated measurement errors. In our opinion, this speaks for itself in favor of the presence in the path of dense ionosphere emission, inasmuch as it is difficult

to assume a notable variation of surface reflection characteristics.

Moreover, comparison of the value of  $\sigma$  taken from the Fig.2 of [8], with the value of the solar radioemission flux in the  $10.6\text{ cm}$  wavelength shows (see Fig.1) that these values vary in antiphase. The uncertainty

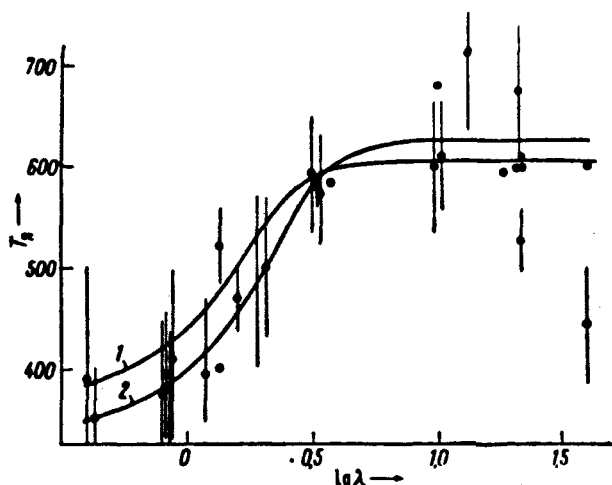


Fig. 2

for the first days of November, where the curve for  $\sigma$  is omitted and for the days from 9 to 15 November, where it is traced with some uncertainty, cannot, apparently, change the general conclusion on the mutually inverse variation of the quantities  $p^{10.7}$  and  $\sigma$ .

This result is difficult to explain from the viewpoint of free passage of radiowaves through the ionosphere and reflection from the

surface. But from the standpoint of porous ionosphere model it is explained quite naturally. According to this model (see Fig.4 in [1]), the reflection of the radiation, having traversed the ionosphere regions free from dense clouds, takes place from Venus' surface. At the same time, the cross section of reflection must be directly proportional to the true

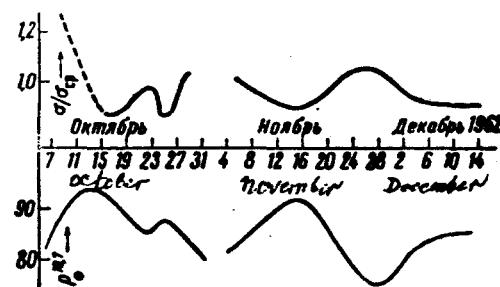


Fig. 1

$T_{br}^{21} = 908, 865$  and  $840^\circ K$ . These values strongly exceed the mean value  $T_{br} = 616^\circ K$  obtained in the work under consideration [6]. The deflections of temperatures from the mean values exceeded in both cases the instrumental errors of measurement. This may be evidence of existence of real variations of Venus' own radioemission temperature, particularly in centimeter and decimeter waves. The presence of such variations is rather difficult to explain from the viewpoint of surface radiation, for the fast variation of temperature or emitting capability of the latter is little probable. At the same time, such variations are quite understandable if the emission in the centimeter and decimeter bands is linked with the ionosphere, which, as is well known from the investigations of the Earth's ionosphere, is quite a dynamic formation.

Therefore, there are at present a series of indications to the fact, that the results of radioastronomical investigations of Venus are apparently linked with its ionosphere. This must be taken into account when interpreting the experimental data independently from what model is involved in the explanation of the total spectrum of brightness temperatures of Venus' radioemission.

As already pointed out in [1], no essential difficulties arise in the porous model ionosphere with the explanation of constancy of reflection cross section obtained in 12 - 70 cm wavelengths. The results of location measurements in 2.5 cm are also quite well explained by this model. As to the possibility of explaining the experimental spectrum of  $T_{br}$ , the presence of three free parameters, as shown in the work [16] by Kuz'min, allows to coordinate practically every spectrum of brightness temperatures with theory, though without additional assumptions there is no possibility of determining the parameters themselves. As an example we present in Fig. 2 the curves 1 and 2, giving somewhat different temperatures in the microwave region and in the region  $\lambda > 10$  cm. These curves are plotted on the basis of porous model ionosphere in the assumption that half of Venus' disk is concealed by dense ionized clouds (porosity factor = 0.5), and the remaining parameters for the curves 1 and 2 are respectively  $T_{\pi} (1 - R) = 380$  and  $350^\circ K$ ;  $T_u = 820$  and  $900^\circ K$ , where  $T_{\pi}$  and  $R$  are the true temperature and the reflection factor of Venus' surface,

Thus, the points of Boischot et al [10], situated somewhat above in the 13 and 21 cm wavelengths, and of Gibson and Corbett [11] in 1.35 cm are obtained in the course of the same period, when the authors of [10] observed an increase in  $T_{br}$  in the 13 and 21 cm wavelengths at time of solar activity increase; from all the points in the 8 mm region at high index of activity\*, a point in 8.6 mm was obtained in [12] ( $T_{br} \approx 410^\circ \text{K}$ ), giving the highest temperature. To the contrary, the Drake points in 21 and 40 cm ( $528$  and  $400^\circ \text{K}$ , respectively) [13] were obtained at a very low solar activity ( $P_{10.7} \sim 80$  un.). For a detailed investigation of the question it is obviously necessary to compare the values of  $T_{br}$  by days of observations with the value of  $P_{10.7}$  or other indices of activity.

The quantities  $T_{br}^{13}$  and  $T_{br}^{21}$ , obtained by Drake [13], apparently speak for themselves against the hotbed model or other models assuming the planet's surface as being the source of emission. In case of radiation by the surface the brightness temperature must be constant for  $\lambda > 2 - 3$  cm, as this was assumed so far in the hotbed model. It would be impossible to postulate, as was done by Drake, that the lowering of temperature at great wavelengths was caused by the decrease in the emitting capability of the surface, since the radar data give the reflection factor of the surface in the 12 - 70 cm region constant values. Besides, there are in 21 cm measurements by other authors, giving temperatures of the order of  $600^\circ \text{K}$ , near the temperatures in 3 and 10 cm and the Findley point in 40 cm [14]; therefore, if the measurements by Drake [13] are correct, one may only speak of brightness temperature variations in 21 and 40 cm.

As is well known, analogous variations of brightness temperatures were observed in a series of other experiments. Thus, in the work [15] by Salomonovich and Kuz'min, it is pointed out that very high brightness temperatures of Venus, exceeding  $1500^\circ \text{K}$ , were observed on certain days in 10 cm, which led to a high mean value of brightness temperature,  $T_{br}^{10} = 690^\circ \text{K}$ .

High values of Venus' brightness temperature in 21 cm were brought out in the work by Clark and Spencer [6]; they were obtained in three experiments effected in the course of one day (27 September 1962);

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\*  $P_{10.7} 250 - 300$  un.

reflection factor of the surface material and to the factor of ionosphere porousness, that is of the relative share of porous and dense regions on the planet's disk. As the solar activity increases, the surface of optically dense regions for a radiation with  $\lambda = 12$  cm must increase, thus leading to a decrease of reflection cross section obtained in these waves during location.

James and Ingless [9] point to the fact that the increase in the reflection cross section in 7.85 m waves ( $\sim 15\%$ ) by comparison with that for waves of the decimeter band ( $\sim 10\%$ ) can be explained by a dense ionosphere, although the explanation of cross section increase in 7.85 cm is estimated in that work as more probable on account of the presence of a surface layer transparent for meter waves and opaque for the centimeter waves.

In October-December 1962, Boischot et al [10] measured the temperature of Venus' own radioemission (eigenstrahlung) in the 13 and 21 cm wavelengths. At the same time an increase of the emission temperature was registered in both wavelengths, which the authors of [10] link with the increase of solar activity during the period from 13 to 17 November. This may probably be an indication of the link between the radiation in the indicated wavelength range with the ionosphere, for in case of hotbed model no such dependence should be observed: indeed, the intensity of solar radiation in the visible region of the spectrum does not undergo noticeable variation.

Inasmuch as the question of dependence of the brightness temperatures, obtained in various wavelengths, on solar radioemission flux offers great interest, we have attempted to find the dependence of the mean values of  $T_{br}$ , brought out in Fig. 2, on  $P_{\odot}^{10.7}$ . However, most of these quantities were obtained as a result of averaging of temperatures measured in the course of several months when the radiation flux varied, and that is why the effect, searched for, should be smoothed. Besides, relatively few measurements were conducted during high solar activity, for most of the experiments refer to latest years, when the solar activity was low. Thus we may point only to certain qualitative conclusions.

and  $T_n$  is the temperature of the dense regions of the ionosphere. As may be seen from Fig. 2, the theoretical curves give a satisfactory agreement with nearly all the experimental data, except for the points of Drake in the 21 and 40 cm wavelength, which were discussed above.

In conclusion it is necessary to note that this work was based upon the material, which, in the opinion of the author, points to the presence at Venus of a dense ionosphere. At the same time, however, there remain some data, which cannot, so far, be interpreted from the ionosphere viewpoint or are even in contradiction with the ionosphere hypothesis. We may refer to these data, for example, the Carpenter conclusion [17] relative to the fact that absorption of waves at 12.5 cm in Venus' atmosphere is small, the result of radar location of Venus in 3.75 cm, giving a low (0.9%) value of the reflection cross section in that wave, the results of the latest experiments by A. D. Kuz'min, etc. It is possible, however, that these results, provided they are reliable, are only evidence that the scheme of Venus' ionosphere is more complex than that considered so far. In any case, the requirement of detailed clarification of the possibilities of the ionosphere hypothesis is still more obvious, than at time of writing the preceding work by the author [1].

\*\*\*\* THE END \*\*\*\*

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